

We Claim:

1. A series fan assembly comprising:
 - 5 a) A primary fan;
 - b) A secondary fan; in series with said primary fan;
 - c) A flow modification element; configured to reduce swirl and mounted between said primary fan and said secondary fan;
 - d) A connecting sleeve,
 - 10 wherein said connecting sleeve directs the output of said primary fan through said flow modification element and into said secondary fan.
2. A series fan assembly as claimed in claim 1, wherein said connecting sleeve further directs the combined output of said primary fan and said secondary fan into an enclosure containing components to be cooled;
 - 15 3. A series fan assembly as claimed in claim 1, wherein said series fan assembly is configured to maintain the combined output of said primary fan and said secondary fan above a minimum level at all times, in the event of the failure of said primary fan or said secondary fan.
 - 20 4. A series fan assembly as claimed in claim 1 further comprising more than two fans connected in series, each separated by a distance and an appropriate said flow modification element.
 5. A series fan assembly as claimed in claim 1 wherein said flow modification element is a filter.
 - 25 6. A series fan assembly as claimed in claim 1 wherein said flow modification element is a heat exchanger.
 7. A series fan assembly as claimed in claim 1 wherein said flow modification element is an electro-magnetic shield.
 8. A series fan assembly as claimed in claim 1 wherein said secondary fan is mounted a distance from said flow control element to reduce acoustic noise.
 - 30 9. A series fan assembly as claimed in claim 1 wherein said flow modification element is comprised of a series of vanes or tubes configured coaxially with said primary fan and said secondary fan.

10. A series fan assembly as claimed in claim 1 wherein said flow modification element is comprised of a series of vanes or tubes configured to create a spiralling laminar flow of air over the fixed blades of said primary fan or said secondary fan when defective.
- 5 11. A series fan assembly as claimed in claim 1 wherein said flow modification element is comprised of a series of tubes with an air funnel at each entry point, said air funnels opening towards and skewed towards the source of the airflow as it comes off the blades of said primary fan.
- 10 12. A series fan assembly as claimed in claim 1 wherein the fan blades of said primary fan and the fan blades of said secondary fan may be configured with adjustable pitch to return to a low airflow impedance position when locked.
- 15 13. A series fan assembly as claimed in claim 1 wherein said primary fan and said secondary fan both normally operate at less than full rotating speed.
- 20 14. A series fan assembly as claimed in claim 1 wherein the rotating speed of said primary fan or said secondary fan may be increased to compensate for the failure of another fan.
- 25 15. A series fan assembly as claimed in claim 1 wherein two or more such series fan assemblies may be mounted in parallel to provide greater performance and fault tolerance.
- 30 16. A series fan assembly as claimed in claim 1 further comprising an indicator means to alert an operator regarding the location and status of a faulty component.
17. A series fan assembly as claimed in claim 1 further comprising a physical means to prevent the accidental reverse installation of said primary fan, said flow modification element, or said secondary fan.
18. A series fan assembly as claimed in claim 1 wherein said primary fan and said secondary fan may rotate in the same or different directions.
19. A series fan assembly as claimed in claim 1 wherein said primary fan and said secondary fan may have the same or different capacity ratings.
20. A series fan assembly as claimed in claim 1 wherein said primary fan and / or said secondary fan may have an integrated stator on the outlet side.
21. A series fan assembly as claimed in claim 1 wherein the direction of flow of said combined output remains consistent in the event of a failure of said primary fan or the failure of said secondary fan.

22. A series fan assembly as claimed in claim 1 further comprising a means to attach said connecting sleeve to said enclosure.

23. A series fan assembly as claimed in claim 1 further comprising sensors attached to said primary fan and said secondary fan, and capable of predicting the impending failure of said primary and said secondary fan.

5 24. A series fan assembly as claimed in claim 1 wherein said connecting sleeve may be configured to accommodate a variety of standard size fans.

25. A series fan assembly as claimed in claim 1 wherein said connecting sleeve may be configured with octagonal corners or other internal features capable of flow modification.

10 26. A series fan assembly as claimed in claim 1 wherein said connecting sleeve and said flow modification element may be configured as a independent module to be later attached to a variety of standard size fans.

27. A series fan assembly as claimed in claim 1 further comprising shims to allow the installation of less than maximum capacity standard sized fans, said shims being installed with said primary fan or said secondary fan to hold it securely in place; wherein said shims may be removed at any time to allow said primary fan or said secondary fan to be upgraded.

15 28. A series fan assembly as claimed in claim 1 wherein said primary fan and said secondary fan form an integral part of said connecting sleeve.

20 29. A series fan assembly as claimed in claim 1 wherein said connecting sleeve is adapted to direct a flow of air into a heat sink.

30. A series fan assembly as claimed in claim 1 wherein said connecting sleeve is adapted to mount obliquely on the cooling fin surface of a heat sink and to direct an impingement flow of air into said heat sink.

25 31. A series fan assembly as claimed in claim 1 further comprising a controller, wherein said controller is configured to maintain said combined output above a minimum control level at all times, in the event of the failure of said primary fan or said secondary fan.

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32. A series fan assembly with baffles comprising:

- a) A primary fan;
- b) A secondary fan; in series with said primary fan;
- c) A flow modification element; configured to reduce swirl and mounted between said primary fan and said secondary fan;
- d) An air inlet baffle configured to allow the free flow of air past said primary fan in response to a failed said primary fan;
- e) An air outlet baffle configured to allow the free flow of air past said secondary fan in response to a failed said secondary fan
- f) At least one sensor monitoring the status of each of said primary fan and said secondary fan;
- g) A power source;
- h) A controller in communication with said sensors, said power source, said primary fan, and said secondary fan;
- i) A connecting sleeve,

wherein said connecting sleeve directs the output of said primary fan through said flow modification element and into said secondary fan; said connecting sleeve further configured to accommodate said air inlet baffle and said air outlet baffle.

33. A series fan assembly with baffles as claimed in claim 32 wherein said connecting sleeve further directs the combined output of said primary fan and said secondary fan into an enclosure containing components to be cooled.

34. A series fan assembly with baffles as claimed in claim 32 wherein said controller is configured to maintain the combined output of said primary fan and said secondary above a minimum control level at all times, in the event of the failure of said primary fan or said secondary fan.

35. A series fan assembly with baffles as claimed in claim 32 further comprising more than two fans connected in series, each separated by an appropriate said flow modification element.

36. A series fan assembly with baffles as claimed in claim 32 wherein said flow modification element is a filter.

37. A series fan assembly with baffles as claimed in claim 32 wherein said flow modification element is a heat exchanger.

38. A series fan assembly with baffles as claimed in claim 32 wherein said secondary fan is mounted a distance from said flow control element to reduce acoustic noise.

5 39. A series fan assembly with baffles as claimed in claim 32 wherein said flow modification element is comprised of a series of vanes or tubes configured coaxially with said primary fan and said secondary fan.

10 40. A series fan assembly with baffles as claimed in claim 32 wherein said flow modification element is comprised of a series of vanes or tubes configured to create a spiralling laminar flow of air over the fixed blades of said primary fan or said secondary fan when defective.

15 41. A series fan assembly with baffles as claimed in claim 32 wherein said flow modification element is comprised of a series of tubes with an air funnel at each entry point, said air funnels opening towards and skewed towards the source of the airflow as it comes off the blades of said primary fan.

20 42. A series fan assembly with baffles as claimed in claim 32 wherein the fan blades of said primary fan and the fan blades of said secondary fan may be configured with adjustable pitch to return to a low airflow impedance position when locked.

43. A series fan assembly with baffles as claimed in claim 32 wherein said primary fan and said secondary fan both normally operate at less than full rotating speed.

25 44. A series fan assembly with baffles as claimed in claim 32 wherein the rotating speed of said primary fan or said secondary fan may be increased to compensate for the failure of another fan.

45. A series fan assembly with baffles as claimed in claim 32 wherein two or more such series fans with baffles may be mounted in parallel to provide greater fault tolerance.

30 46. A series fan assembly with baffles as claimed in claim 32 further comprising an indicator means to alert an operator regarding the location and status of a faulty component.

47. A series fan assembly with baffles as claimed in claim 32 further comprising a physical means to prevent the accidental reverse installation of said primary fan, said flow modification element, or said secondary fan.

48. A series fan assembly with baffles as claimed in claim 32 wherein said primary fan and said secondary fan may rotate in the same or different directions.

49. A series fan assembly with baffles as claimed in claim 32 wherein said primary fan and said secondary fan may have the same or different capacity ratings.

5 50. A series fan assembly with baffles as claimed in claim 32 wherein said primary fan and / or said secondary fan may have an integrated stator on the outlet side.

51. A series fan assembly with baffles as claimed in claim 32 wherein the direction of flow of said combined output remains consistent in the event of a failure of said primary fan or the failure of said secondary fan.

10 52. A series fan assembly with baffles as claimed in claim 32 further comprising a means to attach said connecting sleeve to said enclosure.

53. A series fan assembly with baffles as claimed in claim 32 further comprising sensors attached to said primary fan and said secondary fan, and capable of predicting the impending failure of said primary and said secondary fan.

15 54. A series fan assembly with baffles as claimed in claim 32 wherein said connecting sleeve may be configured to accommodate a variety of standard size fans.

55. A series fan assembly with baffles as claimed in claim 32 wherein said connecting sleeve may be configured with octagonal corners or other internal features capable of flow modification.

20 56. A series fan assembly with baffles as claimed in claim 32 wherein said connecting sleeve and said flow modification element may be configured as a independent module to be later attached to a variety of standard size fans.

57. A series fan assembly with baffles as claimed in claim 32 further comprising shims to allow the installation of less than maximum capacity standard sized fans, said shims being installed with said primary fan or said secondary fan to hold it securely in place; wherein said shims may be removed at any time to allow said primary fan or said secondary fan to be upgraded.

25 58. A series fan assembly with baffles as claimed in claim 32 wherein said primary fan and said secondary fan form an integral part of said connecting sleeve.

59. A series fan assembly with baffles as claimed in claim 32 wherein said connecting sleeve is adapted to direct a flow of air into a heat sink.

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60. A series fan assembly with baffles as claimed in claim 32 wherein said connecting sleeve is adapted to mount obliquely on the cooling fin surface of a heat sink and to direct an impingement flow of air into said heat sink.

5 61. A series fan assembly with baffles as claimed in claim 32 wherein said air inlet baffle and said air outlet baffle may be configured to automatically respond to changes in relative air pressure.

62. A series fan assembly with baffles as claimed in claim 32 wherein the position of said air inlet baffle and said outlet baffle may be controlled by said controller.

10 63. A series fan assembly with baffles as claimed in claim 32 wherein said primary fan and said secondary fan are configured with an offset yet parallel axis, wherein said axis is also parallel to said combined output.

64. A series fan assembly with baffles as claimed in claim 32 wherein said primary fan and said secondary fan may be configured at an angle to said parallel axis, and not necessarily in coaxial fashion.

15 65. A series fan assembly with baffles as claimed in claim 32 wherein said controller is in communication with the operating system associated with the system contained in said enclosure, wherein said operating system may inform said controller of upcoming changes in cooling requirements.

20 66. A series fan assembly with baffles as claimed in claim 32 further comprising a temperature sensor in thermal communication with the component(s) being cooled, wherein said temperature sensor is also in communication with said controller, and wherein said controller may respond to changes the temperature of said component(s).

25 67. A series fan drawer assembly comprising:

- a) A primary fan;
- b) A secondary fan; in series with said primary fan;
- c) A flow modification element; configured to reduce swirl and mounted between said primary fan and said secondary fan;
- d) A connecting sleeve,
- e) A sliding drawer configured to detachably hold said primary cooling fan, said flow modification element, and said secondary cooling fan; said drawer further configured to slide into and out of said connecting sleeve;

5 f) At least one sensor monitoring the status of each of said primary cooling fan and said secondary cooling fan;
g) A power source
h) A controller in communication with said sensors, said power source, said secondary fan, and said primary fan;

wherein said connecting sleeve directs the output of said primary fan through said flow modification element and into said secondary fan.

10 68. A series fan drawer assembly as claimed in claim 67 wherein said connecting sleeve further directs the combined output of said primary fan and said secondary fan into an enclosure containing components to be cooled;
69. A series fan drawer assembly as claimed in claim 67 wherein said controller is configured to maintain the combined output of said primary fan and said secondary fan above a minimum control level at all times, in the event of the failure of said primary fan or said secondary fan.
15 70. A series fan drawer assembly as claimed in claim 67 further comprising more than two fans connected in series, each separated by an appropriate said flow modification element.
20 71. A series fan drawer assembly as claimed in claim 67 wherein said flow modification element is a filter.
72. A series fan drawer assembly as claimed in claim 67 wherein said flow modification element is a heat exchanger.
25 73. A series fan drawer assembly as claimed in claim 67 wherein said flow modification element is an electro-magnetic shield.
74. A series fan drawer assembly as claimed in claim 67 wherein said secondary fan is mounted a distance from said flow control element to reduce acoustic noise.
30 75. A series fan drawer assembly as claimed in claim 67 wherein said flow modification element is comprised of a series of vanes or tubes configured coaxially with said primary fan and said secondary fan.
76. A series fan drawer assembly as claimed in claim 67 wherein said flow modification element is comprised of a series of vanes or tubes configured to create a spiralling laminar flow of air over the fixed blades of said primary fan or said secondary fan when defective.

77. A series fan drawer assembly as claimed in claim 67 wherein said flow modification element is comprised of a series of tubes with an air funnel at each entry point, said air funnels opening towards and skewed towards the source of the airflow as it comes off the blades of said primary fan.

5 78. A series fan drawer assembly as claimed in claim 67 wherein the fan blades of said primary fan and the fan blades of said secondary fan may be configured with adjustable pitch to return to a low airflow impedance position when locked.

79. A series fan drawer assembly as claimed in claim 67 wherein said primary fan and said secondary fan both normally operate at less than full rotating speed.

10 80. A series fan drawer assembly as claimed in claim 67 wherein the rotating speed of said primary fan or said secondary fan may be increased to compensate for the failure of another fan.

15 81. A series fan drawer assembly as claimed in claim 67 wherein two or more such series fan drawer assemblies may be mounted in parallel to provide greater fault tolerance.

82. A series fan drawer assembly as claimed in claim 67 further comprising an indicator means to alert an operator regarding the location and status of a faulty component.

20 83. A series fan drawer assembly as claimed in claim 67 further comprising a physical means to prevent the accidental reverse installation of said primary fan, said flow modification element, or said secondary fan.

84. A high performance series fan drawer assembly as claimed in claim 53 wherein said primary fan and said secondary fan may rotate in the same or different directions.

25 85. A series fan drawer assembly as claimed in claim 67 wherein said primary fan and said secondary fan may have the same or different capacity ratings.

86. A series fan drawer assembly as claimed in claim 67 wherein said primary fan and / or said secondary fan may have an integrated stator on the outlet side.

30 87. A series fan drawer assembly as claimed in claim 67 wherein the direction of flow of said combined output remains consistent in the event of a failure of said primary fan or the failure of said secondary fan.

88. A series fan drawer assembly as claimed in claim 67 further comprising a means to attach said connecting sleeve to said enclosure.

89. A series fan drawer assembly as claimed in claim 67 further comprising sensors attached to said primary fan and said secondary fan, and capable of predicting the impending failure of said primary and said secondary fan.

5 90. A series fan drawer assembly as claimed in claim 67 wherein said connecting sleeve may be configured to accommodate a variety of standard size fans.

91. A series fan drawer assembly as claimed in claim 67 wherein said connecting sleeve may be configured with octagonal corners or other internal features capable of flow modification.

10 92. A series fan drawer assembly as claimed in claim 67 further comprising shims to allow the installation of less than maximum capacity standard sized fans, said shims being installed with said primary fan or said secondary fan to hold it securely in place; wherein said shims may be removed at any time to allow said primary fan or said secondary fan to be upgraded.

15 93. A series fan drawer assembly as claimed in claim 67 wherein said primary fan and said secondary fan form an integral part of said connecting sleeve.

94. A series fan drawer assembly as claimed in claim 67 wherein said controller is in communication with the operating system associated with the system contained in said enclosure, wherein said operating system may inform said controller of upcoming changes in cooling requirements.

20 95. A series fan drawer assembly as claimed in claim 67 further comprising a temperature sensor in thermal communication with the component(s) being cooled, wherein said temperature sensor is also in communication with said controller, and wherein said controller may respond to changes the temperature of said component(s).

25 96. A series fan drawer assembly as claimed in claim 67 further comprising a redundant indicator means to confirm the identity of the faulty component, said redundant indicator means being visible when said sliding drawer is pulled out from said enclosure.

97. A high performance series fan drawer assembly as claimed in claim 53 wherein said sliding drawer may be pulled out from said enclosure in a limited and controlled fashion while the system within said enclosure is still in operation.

30 98. A series fan drawer assembly as claimed in claim 67 wherein said primary fan, said flow modification element, or said secondary fan may be replaced while said

drawer is pulled out from said enclosure and while the system within said enclosure is still in operation.

99. A series fan drawer assembly as claimed in claim 67 wherein said sliding drawer may be completely removed from said connecting sleeve and said enclosure when required.

100. A series fan drawer assembly as claimed in claim 67 wherein said controller is in communication with the operating system associated with the system contained in said enclosure, wherein said operating system may inform said controller of upcoming changes in cooling requirements.

101. A series fan drawer assembly as claimed in claim 67 further comprising a temperature sensor in thermal communication with the component(s) being cooled, wherein said temperature sensor is also in communication with said controller, and wherein said controller may respond to changes the temperature of said component(s).

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